REMARKS

Please reconsider the application in view of the above amendments and the following remarks. Applicant thanks the Examiner for carefully considering this application. Further, the Applicant respectfully requests prompt action on the merits of this case, as the Applicant originally believed to have secured the allowance of these claims on March 11, 2003.

I. Disposition of Claims

Claims 1-21 and 23-28 were held as allowable in a Notice of Allowance dated March 11, 2003. On December 3, 2003, the application was withdrawn from issue and reassigned to Examiner Ferris in Art Group 2128. Currently, claims 1-21 and 23-28 are pending in this application. Claims 1-9, 16-21, 23, 24, and 26-28 have been cancelled by this reply. Only claims 10-15 and 25 are now pending. Of the remaining claims, claims 10 and 25 are independent. Claims 11-15 depend, directly or indirectly, from claim 10.

II. Rejection(s) under 35 U.S.C § 112

First Paragraph Rejections

Claims 1-21 and 23-28 stand rejected under 35 U.S.C. §112, first paragraph. In particular, the specification was not considered to sufficiently disclose "simulating drilling of an earth formation" as recited in the claims. Claims 1-9 and 16-21, 23, 24, and 26-28 have been cancelled by this reply rendering the rejection moot with respect to these claims. Regarding claims 10-15 and 25, the Applicant respectfully disagrees.

Written Description

It appears, given the nature of the rejection, that the Examiner believes that the specification fails both the written description and enablement requirements set forth in 35 U.S.C. § 112, ¶ 1. With respect to the written description requirement, MPEP §2163.02 states:

> "[w]henever the issue arises, the fundamental factual inquiry is whether the specification conveys with reasonable clarity to those skilled in the art that, as of the filing date sought, applicant was in possession of the invention as now claimed. An applicant shows possession of the claimed invention by describing the claimed invention with all of its limitations using such descriptive means as words, structures, figures, diagrams, and formulas that fully set forth the claimed invention."

Citing Lockwood v. American Airlines, Inc., 107 F.3d 1565, 1572 (Fed. Cir. 1997).

Further, the Applicant notes that pursuant to MPEP §2163.04, a specification is *presumed* to be adequate. "The Examiner bears the burden to show why a person skilled in the art would not recognize in an applicant's disclosure a description of the invention defined by the art." In his rejection, the Examiner asserts that the Applicant's failure to disclose mathematical formulas is a fatal flaw.

First, the Applicant respectfully asserts that there is no "mandatory mathematical formula" requirement found in the statute or rules. The Applicant submits that there is no need for mathematical equations or formulas to convey how axial forces and axial displacement are calculated in the present invention. Second, in the present invention, the Applicant submits that formulas would only serve to obscure the present invention.

As discussed in detail below, the specification conveys with reasonable specificity how to determine axial forces, how to compare axial forces, and how to design drill bits

using those forces. The Examiner cannot overcome the presumption of adequacy merely by nakedly asserting that the Applicant should have disclosed more. Rather, the proper test for determining sufficiency of description is "whether the specification conveys with reasonable clarity to those skilled in the art that, as of the filing date sought, applicant was in possession of the invention as now claimed." MPEP §2163.04

It is unarguable that an algorithm for simulating drilling of an earth formation is disclosed in the specification. The disclosure of the algorithm is inclusive of calculating (or determining) (1) axial forces and (2) axial movement.

Claim 25 recites the limitation of "simulating the bit drilling through a selected earth formation," which is clearly disclosed in the specification. For example, an algorithm for simulating drilling of an earth formation by a roller cone bit is shown in Figures 3A and 3B reproduced below.
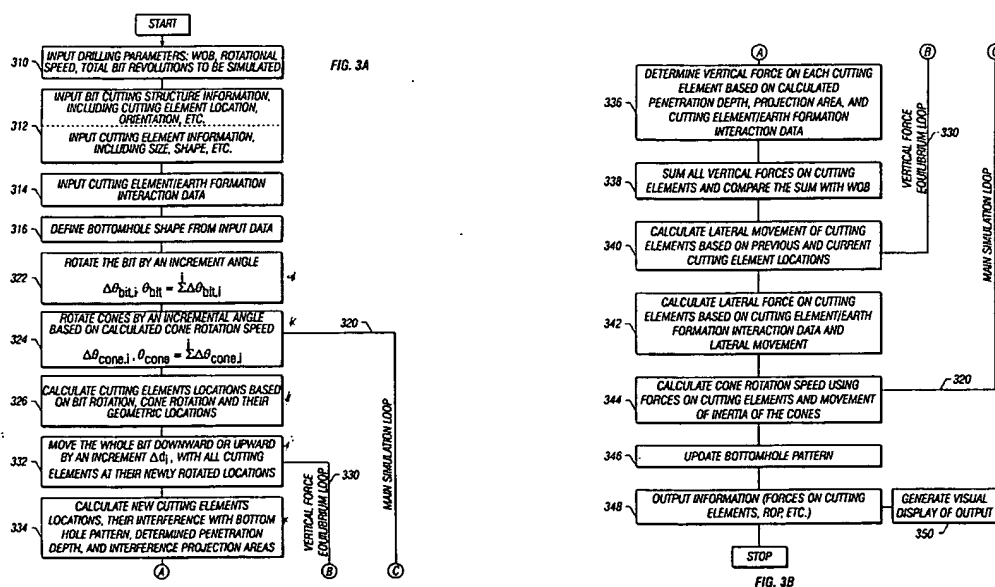
Figures 3A and 3B of the Specification

For example, a main simulation loop (320) is indicated in the above figures. The

specification states the following with respect to the main simulation loop (320)—

> To summarize the functions performed in the main simulation loop 320, drilling simulation is incrementally calculated by "rotating" the bit through an incremental angle, and then iteratively determining the vertical (axial) displacement of the bit corresponding to the incremental bit rotation. Once the vertical displacement is obtained, the lateral forces on the cutting elements are calculated and are used to determine the current rotation speed of the cones. Finally, the bottomhole geometry is updated by removing the deformed earth formation resulting from the incremental drilling calculated in the simulation loop 320.

Similar descriptions appear throughout the specification with regard to each of the elements shown in the above figures. Because the specification clearly discloses simulating a roller cone drill bit in the earth formation, withdrawal of this §112 rejection with respect to claim 25 is respectfully requested.

Claim 10 recites "simulating drilling an earth formation by the roller cone bit, the simulating comprising *calculating*, from a geometry of cutting elements on each of the roller cones and at least one characteristic of an earth formation being drilled by the drill bit, *an axial force acting on each of the cutting elements*" (emphasis added).

The specification also discloses "simulating comprising . . . calculating an axial force acting on each of the cutting elements" in the sub-section entitled "Cutting Element/Earth Formation Interaction Data" (pp. 15-21 of the specification). This section details how the cutting element/earth interaction data is obtained and how this data is used in the simulating of the roller cone bit, and, specifically, calculating axial forces.

In one or more embodiments, the cutting element/earth interaction data comprises a library of data obtained from impact tests.

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The specification states,

> [i]n an impact test, a selected cutting element is impressed on a selected
> earth formation sample with a selected applied force to more accurately
> represent bit action. The force applied may include an axial component and/or a
> lateral component. The cutting element is then removed, leaving behind a crater
> in the earth formation having an interference depth *b*, for example, as shown in
> Fig. 8A" (p. 16, ll. 16-20).

The cutting element parameters, earth formation parameters, and force parameters
are stored in a library, in addition to crater information, which relates to shape and size of
the crater formed during the impact test. The specification also states:

> [t]he test is then repeated for the same cutting element in the same earth
> formation under different applied loads, until a sufficient number of tests are
> performed to characterize a relationship between the interference depth and the
> impact force applied to the cutting element (p. 17, ll. 1-4).
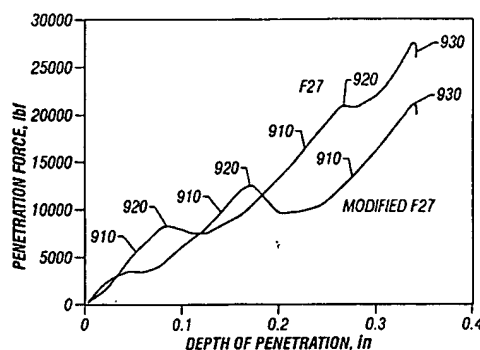

Figure 9 of the Specification

Fig. 9 shows a graph of one example of typical experimental results obtained from
impact test using two different insert-type cutting elements in an earth formation. The
two different inserts are identified as "Original Insert" and "Modified Insert." Each insert
is represented by a depth/force curve to characterize the relationship between the

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interference depth and force for the insert in the selected formation, respectively.

Further, the specification more specifically discusses the cutting element/earth formation interaction data, stating:

> [t]o obtain a complete library of cutting element/earth formation interaction data, subsequent impact tests are performed for each selected cutting element and earth formation up to the drop-off value (*i.e.*, maximum depth of penetration of the cutting element) to capture crater size at the particular depth/force. The entire depth/force curve is then digitized and stored. Linear interpolation, or other types of best-fit function, can be used in this embodiment to obtain depth of penetration values for force values between measurement values experimentally obtained (p. 18, ll. 1-8).

When the simulated drill bit is "rotated" and "moved" downward by a selected increment, new locations of the cutting elements are determined (based kinematics that are well known in the art). Fig. 8C, reproduced below, is a graphical representation of a roller cone drill bit penetrating the earth formation.
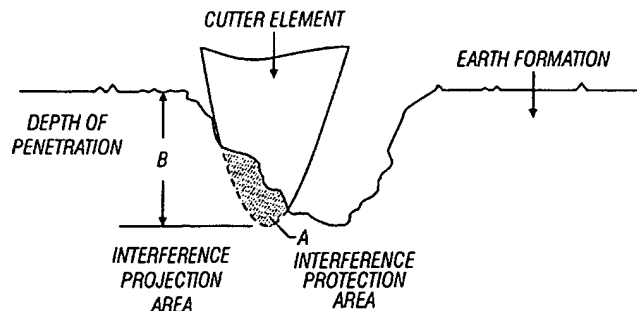

FIG. 8C

Figure 8C of the Specification

Using the determined depth of penetration (*e.g.*, B), the force exerted by a cutting element on the earth formation can be calculated using an established relationship

between the depth of penetration and force for a particular cutting element, for example, as shown in Fig. 9.

Because the specification readily discloses how forces are calculated in the present invention, withdrawal of the §112 rejection with respect to claim 10 is respectfully requested.

Additionally, claim 12, which depends from claim 10, recites "*an incremental axial movement* of the drill bit corresponding to the incrementally rotating." (emphasis added). This incremental axial movement is fully defined by the specification. For example, the specification states "the bit is 'moved' (axially) downward (numerically) *a selected initial incremental distance* Δd_i and the new cutting element locations p_i are calculated" (p. 9, ll. 24-26).

In other words, this "incremental axial movement" is selected by the user. Additionally, despite the user's selection (*i.e.*, even if it is a poor selection), the specification discloses an equilibrium loop (330 in Figure 3A and 3B), which internally checks the accuracy of the selected incremental distance. (The equilibrium loop (330) is explained in detail on pp. 9-11.)

Because the instant specification in the above paragraphs readily discloses how axial movement is calculated in the present invention, withdrawal of the §112 rejection with respect to claim 12 is respectfully requested.

The remaining claims, 11 and 13-15, include claim language or depend from claims relating to the calculation or determination of (1) axial forces and/or (2) axial movement. For at least the above reasons, the remaining claims are fully supported by the instant specification. Accordingly, withdrawal of §112 rejection with respect to the

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remaining claims is respectfully requested.

In sum, the Applicant respectfully notes that the MPEP provides that various methods may be used to describe the invention, and formulas are by no means an absolute requirement for describing an invention. Moreover, the Applicant submits that formulas in themselves are of no utility without words and figures to explicate their meaning. With respect to the present invention, the words and figures provide a description that clearly and succinctly conveys the limitations of the present invention.

Enablement

The Applicant notes that the above discussion, with reference to the specification and figures, also illustrates that the present specification properly enables all of the claimed subject matter. In particular, the Applicant notes that the appropriate test for determining whether a particular claim is enabled is whether a person skilled in the art "can make and use the invention without undue experimentation." *In re Wands*, 858 F.2d 731, 737 (Fed. Cir. 1988).

Under MPEP 2164.01(a) a number of factors should be considered when determining whether a given claim is enabled by the disclosure. "It is improper to conclude that a disclosure is not enabling based on an analysis of only one of the factors while ignoring one or more of the others. The examiner's analysis must consider all of the evidence related to each of these factors, and any conclusion of nonenablement must be based on the evidence as a whole." (Emphasis added) MPEP 2164.04(a) quoting *In re Wands*, 858 F.2d 731, 740 (Fed. Cir. 1988)).

In short, the determination of nonenablement is not a single, simple factual determination, but must be a conclusion reached by weighing all of the relevant factual

considerations. The Applicant respectfully submits that the Examiner has failed to consider these factors in reaching a conclusion that the specification does not enable the invention. For this reason alone, therefore, the rejection is untenable, and it is respectfully requested that the rejection be withdrawn.

However, to the extent that the Examiner has considered the enumerated factors, the Applicant respectfully submits that the Examiner did not consider the appropriate level of one of ordinary skill in the art, the amount of direction provided by the inventor, the nature of the invention (*i.e.*, simulating drilling), and the state of the prior art.

The Applicant respectfully asserts that all of these factors weigh heavily on the side of the Applicant, namely that the relevant person of ordinary skill would be a person having knowledge of both mechanical and software engineering. Moreover, drill bit kinematics (as evidenced by the Ma book) are sufficiently understood by a person having skill in the art so as to render descriptions of the motion of a bit unnecessary. Further, as the passages cited above indicate, the Applicant has provided a great deal of direction to those having skill in the art to make and use the claimed invention.

For all of these reasons, the Applicant respectfully asserts that the §112, ¶1 rejections are untenable and respectfully requests that they be withdrawn.

Second Paragraph Rejections

Claims 25 and 26 were rejected under 35 U.S.C. §112, second paragraph. In particular, the term "substantially balanced" is allegedly not sufficiently defined, thereby rending these claims indefinite. Claim 26 has been cancelled rendering this rejection moot. Claim 25 has been amended in this reply. Withdrawal of this rejection is respectfully requested with respect to amended claim 25.

Claim 25 has been amended to recite "repeating the adjusting and simulating until

a distribution of an axial force on the bit is substantially balanced between roller cones."

The specification discusses that a distribution of axial force may be used as drilling

characteristic used in the bit design process. For example, the specification states—

> An optimal set of bit design parameters may be defined as a set of bit
>
> design parameter which produces a desired degree of improvement in drilling
>
> performance, in terms of rate of penetration, cutting element wear, <u>optimal axial</u>
>
> <u>force distribution between cones</u>, between rows, and between individual cutting
>
> elements, and/or optimal lateral force distributions on the bit (p. 23, ll. 5-9).

Additionally, the specification provides graphical representation of displays

generated to analyze the effects of drilling on the cones and cutting elements on the bit.

In particular, Fig. 6G shows a graphical summary of the force distribution on the cones as
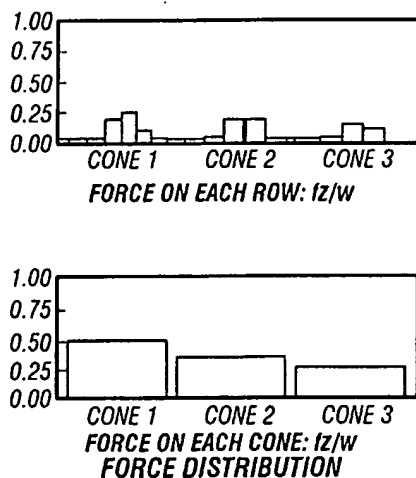
provided below.

FIG. 6G

Figure 6G of the Specification

As described in the specification, "[t]he top graph provides a summary of the

forces acting on each row of each cone on the bit. The bottom graph in Fig. 6G is a

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summary of the distribution of force between the cones of the bit" (p. 14, ll. 15-18). Thus in view of the graphical displays of output of the present invention, for example, as shown in the bottom graph of Figure 6G, one of ordinary skill in the art would be able to ascertain the meaning of "substantially balanced between the roller cones."

Moreover, the Applicant respectfully notes that the term "substantially" is not indefinite. The Federal Circuit has repeatedly held that "words of approximation, such as generally and substantially are descriptive terms commonly used in patent claims to avoid a strict numerical boundary to the specified parameter," and, therefore, are allowable to use as an approximate limitation on the scope of the claim. *Liquid Dynamics Corp. v. Vaughn Co., Inc.*, 355 F.3d 1361, 1368 (Fed. Cir. 2004).

Because the specification clearly discloses a distribution of axial force between cones, in addition to providing an example of a graphical representation that may be used to evaluate the distribution of axial force between cones, the term "substantially balanced" in amended claim 25 is defined. Accordingly, withdrawal of this rejection is respectfully requested.

III.   Objections

The specification has been objected to for allegedly, improperly incorporating subject matter of a reference that contains matter which is critical to the operation of the claimed invention for supporting the claim limitations, namely, "The Computer Simulation of the Interaction Between Roller Bit and Rock," ("the Ma paper") authored by Dekun Ma. The Applicant respectfully disagrees for at least the reasons as outlined in the remarks to the §112, first paragraph, rejection.

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In short, the Applicant submits that the instant specification adequately discloses (1) how related calculations are performed; (2) what the forces are and how they are calculated; and (3) optimization and balancing roller cone design. Further, the Applicant submits that the provision of formulas is not necessary to adequately disclose all of the limitations of the present invention. Finally, algorithms for calculating forces acting on the simulated bit and the interference with the earth formation is disclosed throughout the specification and depicted in Fig.(s) 3A and 3B; 10A and 10B; and 11A and 11B. Because the specification does not rely on the Ma paper to support the limitations of the claims, withdrawal of this objection is respectfully requested.

IV.   Double Patenting

Claims 1, 5, 23, 24, 27, and 28 were rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1-9 of U.S. Patent No. 6,527,068 ("Singh"). These claims have been cancelled in this reply rendering the double patenting rejection moot.

V.   Rejection(s) under 35 U.S.C § 102

Chen '225

Claims 1-21 and 23-28 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,213,225 ("Chen '225"). Claims 1-9, 16-21, 23, 24, and 26-28 have been cancelled by this reply rendering this rejection moot with respect to these claims. With respect to claims 10-15 and 25, this rejection is respectfully traversed.

The Applicant submits a declaration, pursuant to 37 C.F.R. §1.131, by Sujian

Huang and Chris Cawthorne (the named inventors of the instant application), which establishes the prior invention of the present application with respect to the §102(e) date of Chen '225, *i.e.*, August 31, 1998. The attached declarations and exhibits provide evidence that the named inventors of the present application, in fact, invented the claimed subject matter prior to August 31, 1998. Thus, Chen '225 has been antedated. Accordingly, Chen '225 has been removed as a valid prior art reference thereby rendering this rejection moot. Therefore, withdrawal of this rejection is respectfully requested.

The Ma Book

Claims 1, 5, and 23, 24, 27, and 28 were rejected under 35 U.S.C. §102(b) as being anticipated by "The Operational Mechanics of the Rock Bit," ("the Ma book") authored by Dekun Ma. Claims 1-9, 16-21, 23, 24, and 26-28 have been cancelled by this reply rendering this rejection moot with respect to these claims. With respect to claims 10-15 and 25, this rejection is respectfully traversed.

The Ma book discloses, as indicated by its title, the operational mechanics of a roller cone rock bit. In other words, the Ma book is a study of the kinematics of a roller cone rock bit in the earth formation. To understand the kinematics of a roller cone rock bit in earth formation, the Ma book is partitioned into six chapters, namely, "Introduction" relating to the history of roller cone rock bit development; "The Geometry of the Rock Bit" relating to the physical characteristics of a roller cone rock bit; "The Kinematics of the Rock Bit" relating to the dynamic characteristics of a roller cone rock bit; "The Bearing System of the Rock Bit" primarily relating to bearing wear; "The Experimental Study on the Interaction Between Bit and Rock" examining the relationship

between a tooth on a roller cone rock bit and the earth formation; and "The New Methodology for the Rock Bit Design" previewing a design methodology by combining the understanding found in the previous chapters.

The first chapter of Ma sets forth the objective of the book as follows:

> When the rock bit is studied or designed by means of this technological system, the dependence on experience will be reduced, the time for comparing design schemes will be decreased, the most calculation and optimization in the bit designing will be done by the aid of computer, and the bit engineering drawings will be drawn by computer. In short, the rate and the quality of bit design will be improved significantly. The performance design and the mechanical design of rock bit now begin to jump from the empirical to the scientific level. The main contents of the book will present those research results (p. 17 of the Ma book).

Here, the Ma book has been constructed to establish a relationship between mechanical (or geometric) design and performance design, which was previously understood solely through observation.

The last chapter, the shortest chapter of the book, returns to the objective set out in the introduction. Here, Chapter 6 addresses the two issues of design, *i.e.*, geometrical design and performance design (pp. 227-228 of the Ma book). The Ma book characterizes the benefits of the disclosed design method:

> The new bit design technology has the following destinctive [sic] features in contrast to the traditional design method. The rock bit is a short life tool. The main approach to improving the bit performance is that the performance and life of the parts should be properly matched [to] each other. The prerequisite for this approach is to evaluate the size, load, motion, stress and strain of every part

accurately. The traditional method just could not do this. It could not evaluate the velocity of tooth, the number of contacting teeth, the load distribution to parts, and only determines the sizes to the millimeter [sic] level by the projective geometry drawings. While the new method can calculate the micrometer level in size and the mm/s level in tooth velocity, if necessary. In a word, the new design technology increases the design precision, and the accuracy of most calculated data, and reduces the dependence on experience.

Pg. 232 of the Ma book.

The Ma book does *not*, however, disclose or suggest an iterative process to improve the distribution of forces on a drill bit as required by claim 25, nor does it disclose reducing the differences in axial force by repeating a design of a bit.

As previously noted, the present invention as recited in claims 10 and 25 specifically require that a particular criteria is met when designing a roller cone drill bit. For example, claim 10 recites, "adjusting at least one bit design parameter, and repeating the simulating until a difference between the combined axial force on each of the roller cones is less than a difference between the combined axial force determined prior to adjusting the at least one initial design parameter." Additionally, claim 25 recites, "repeating the adjusting and simulating until a distribution of an axial force on the bit is substantially balanced between the roller cones."

The present invention as recited in claims 10 and 25 recite an objective criteria based on quantitative results of simulating a roller cone drill bit in earth formation that is independent of the designer.

Because the Ma book does not close the present invention as recited in claims 10 and 25, claims 10 and 25 are patentable over the Ma book. Claims 11-15, which depend from claim 10, are patentable for at least the same reasons. Accordingly, withdrawal of

this rejection is respectfully requested.

VI.   Rejection(s) under 35 U.S.C § 103

Chen '262 and the Ma paper

Claims 1-9, 23, 24, 27, and 28 were rejected under 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,095,262 ("Chen '262") in view of an article entitled, "The Computer Simulation of Interaction Between Roller Bit and Rock," authored by Dekun Ma *et al* (hereinafter "the Ma paper"). Claims 1-9, 23, 24, 27, and 28 have been cancelled by this reply. This rejection is now rendered moot. Accordingly, withdrawal of this rejection is respectfully requested.

Chen '262, the Ma paper, & Chen '225

Claims 10-21, 25, and 26 were rejected under 35 U.S.C. §103(a) as being unpatentable over Chen '262 in view of the Ma paper, in further view of Chen '225. Claims 16-21 and 26 have been cancelled by this reply. Therefore, the rejection with respect to these claims has been rendered moot. Accordingly, withdrawal of the §103 rejection with respect to claims 16-21 and 26 is respectfully requested.

Additionally, both Chen '225 and '262 qualify as prior art under §102(e). The Applicant submits a declaration by Sujian Huang and Chris Cawthorne, which establishes the reduction to practice of the present invention prior to the §102(e) date of Chen '225 and '262, *i.e.*, August 31, 1998. The attached declarations and exhibits provide copious amounts of evidence that the named inventors of the present application, in fact, invented the claimed subject matter prior to August 31, 1998. Thus, Chen '225 and '262 have

been removed as valid prior art references. The Applicant respectfully asserts that the Ma paper by itself fails to render claims 10-15 and 25 obvious.

Similar to the Ma book, the Ma paper teaches the kinematics of a roller cone rock bit interacting with earth formation as it relates to computer simulation. In the Ma paper, the article is also partitioned into sections to teach this subject matter. In particular, the Ma paper teaches the mathematical background for the BRIAS (Bit-Rock Interaction Simulation) through various formulas, in addition to the simulation model of BRIAS. In the conclusion, the Ma paper teaches the various uses of the BRIAS software.
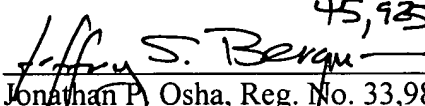
The Ma paper does *not* teach "adjusting at least one bit design parameter, and repeating the simulating until a difference between the combined axial force on each of the roller cones is less than a difference between the combined axial force determined prior to adjusting the at least one initial design parameter" or "repeating the adjusting and simulating until a distribution of an axial force on the bit is substantially balanced between the roller cones," as required by claims 10 and 25, respectively. Dependent claims 11-15 are also patentable for at least the same reasons. Accordingly, withdrawal of this rejection is respectfully requested.

VI. Conclusion

Applicant believes this reply is fully responsive to all outstanding issues and places this application in condition for allowance. If this belief is incorrect, or other issues arise, the Examiner is encouraged to contact the undersigned or his associates at the telephone number listed below. Please apply any charges not covered, or any credits, to Deposit Account 50-0591 (Reference Number 05516.056002).

Respectfully submitted,

Date: 3/22/04

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